U. S. NATIONAL RESEARCH TRENDS IN MTHEMATICS & INTELLIGENT CONTROL (A PERSPECTIVE FROM THE US ARMY RESEARCH OFFICE)

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ABSTRACT

This presentation will address current thinking for mathematics research in the minds of our national leaders in the (US) Army and the links to the current interest in the mathematics community. Pertaining to the interest of this Workshop, research issues of intelligent systems and control will be touched on as well.

A. TRENDS IN DOD/ARMY FUNDING IN MATHEMATICS RESEARCH

Lessons learned from the recent Bosnia combat: Could not bring heavy tanks in time. Helicopters were not used to avoid casualty. We need lighter systems, with the same or improvement requirements as before. We shall list several research areas where breakthroughs are urgently needed:

1. Mathematics for Materials:

Materials by Design - Optimization on Microstructures
Energy Source - Compact Power, Energy Efficiency
Nonlinear Dynamics and Optimal Control

2. Security Issues In The Information Age

Needs in critical infrastructure protection
Mathematics for Information & Communication
Mathematics for Sensors (Information/Data Mining & Fusion)
Information on the Move (Mobile Communication)
Network Security and Protection

3. Demands In Software Reliability

It is common to have tens of thousands lines of codes in a computer program and it is important that the program runs correctly and efficiently. Hence one needs “science and engineering” for software and mathematics for computer language, architecture, etc.

4. Requirements for Automated Decision Making

To make precision decisions based on imprecise data:
Probability, Likelihood, Stochastic Analysis
Mathematics of Sensing, Image, Pattern Analysis, Spectral Analysis

5. Future Systems (Push Technology To Its Limit)

Lighter Vehicles, Smaller satellites
ICBM Interceptors, Hit before being hit
Secured Wireless Communication Systems
Super Efficient Energy/Power Source
Modeling and Simulation, Robotics and Automation

B. THE IMPORTANCE OF MATHEMATICS (ROLES IT WILL PLAY)

Mathematics Issues:
Mathematical Analysis generalized (Mathematics for Materials
Discrete Mathematics of All Objects
(Security Issues In The Information Age, Demands In Software Reliability)
Stochastic Analysis
(Automated Decision-Making: Based on imprecise data)
Mathematics of Novel Computer/Computing
(Quantum and Bio-Computer/Computing)

AMS (American Mathematics Society) Expositions of Current Interest (Allyn Jackson), A List of 16 Topics:

The Mathematics of Data Encryption
Mathematics Unlocks Mysteries of the Universe
The Mathematics of Data Networks
The Motivation Behind Motivic Cohomology
International Team Shows that Primes Can Be Found in Surprising Places
Dallas Banker Offers $50,000 Prize for Solution of Mathematics Problem
From Modems to Satellite Photos
Banking on Mathematics: The Importance of Prime Factorization Sieves
Mathematics Provides Tools for Financial Decisionmaking
The Mathematics of Image Compression
Can DNA Compute?
Is Voting Really Fair?
A Revolution in Mathematics
Math Tool Helps FBI Store Fingerprints
n-Body Problems
Mathematics of DNA

C. CROSS LINKS

Mathematics of Novel Computer/Computing
(Quantum and Bio-Computer/Computing)
Can DNA Compute? Mathematics of DNA

Mathematical Analysis generalized
Discrete Mathematics of All Objects
Stochastic Analysis

Data Mining / Fusion / Heterogeneous Information
Mathematics of Information & Security
Mathematics of Information & Security Issues
The Mathematics of Data Encryption
The Mathematics of Data Networks
Math Tool Helps FBI Store Fingerprints
From Modems to Satellite Photos
The Mathematics of Image Compression
Demands In Software Reliability
Security Issues In The Information Age
Automated Decision-Making: Based On Imprecise Data

Mathematical Analysis Generalized: Discrete Mathematics of All Objects
n-Body Problems
The Motivation Behind Motivic Cohomology
International Team Shows that Primes Can Be Found in Surprising Places
Mathematics Unlocks Mysteries of the Universe

D. TRENDS IN DOD/ARMY RESEARCH IN INTELLIGENT SYSTEMS

The future automated systems will likely be multiple units, each are "small" in size, light in weight, very efficient in energy utilization and still extremely fast in speed. These unites will likely to be "self-organized" and coordinated to perform a specific task. These systems are typically complex and nonlinear. The research issues are many and exciting. In terms of "intelligent control" disciplines, they might be assembled into the following categories:

1 Hierarchical Control for Multiple Agents, 2. Distributed Systems,
3. Intelligent Systems, 4. Mobile Agents, ETC.

Among the current DOD research programs, these trends are reflected by the following activities:

1. An ARO MURI on Integrated control and communication for networked systems.
2. An AFOSR MURI on Cooperative control of distributed autonomous agents in dynamic, uncertain, adversarial environments.
3. A planned research program on Control of nonlinear dynamics and complex systems.
4. An ARO MURI on Intelligent systems and control.
5. An ARO MURI on Control of smart materials and adaptive structures.
6. A planned research program on Control applications in biological and medical systems.
7. An ARO MURI on Mathematics of failures in complex systems.
8. An ARO MURI on Data fusion in large arrays of microsensors (sensorweb).